UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/760,884	01/17/2001	Panayotis C. Andricacos	YOR20000578US1	4972

7590 06/25/2004

Connolly Bove Lodge & Hutz LLP
Suite 800
1990 M Street, N.W.
Washington, DC 20036-3425

EXAMINER	
MUTSCHLER, BRIAN L	

ART UNIT	PAPER NUMBER
1753	

DATE MAILED: 06/25/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
P.O. Box 1450
ALEXANDRIA, VA 22313-1450
www.uspto.gov

BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 09/760,884
Filing Date: January 17, 2001
Appellant(s): ANDRICACOS ET AL.

John Evans
For Appellant

MAILED
JUN 25 2004
GROUP 1700

EXAMINER'S ANSWER

This is in response to the appeal brief filed May 10, 2004.

(1) Real Party in Interest

A statement identifying the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

A statement identifying the related appeals and interferences which will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is contained in the brief.

(3) Status of Claims

The statement of the status of the claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Invention

The summary of invention contained in the brief is correct.

(6) Issues

The appellant's statement of the issues in the brief is substantially correct. The changes are as follows: Appellant filed an after final amendment on February 9, 2004, which was entered. This amendment incorporated limitations from claims 21 and 23

into independent claim 10. As indicated in the advisory action mailed March 19, 2004, the rejection of the claims is maintained over the combination of Chen (WO 99/47731) in view of Landau (U.S. Pat. No. 6,261,433) and in view of Ting et al. (U.S. Pat. No. 5,969,422). The rejection of each limitation in the claims remains unchanged.

(7) Grouping of Claims

The rejection of claims 10-23 and 29-30 stand or fall together as indicated by the statement in appellant's brief. See 37 CFR 1.192(c)(7).

(8) Claims Appealed

The copy of the appealed claims contained in the Appendix to the brief is correct.

(9) Prior Art of Record

WO 99/47731	Chen	09-1999
US 6,261,433	Landau	07-2001
US 5,969,422	Ting et al.	10-1999

(10) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 10-22 and 29-30 are rejected under 35 U.S.C. 103(a) as being unpatentable over WO 99/47731 (herein referred to as WO '731) in view of LANDAU (U.S. Pat. No. 6,261,433) and in view of TING et al. (U.S. Pat. No. 5,969,422).

Regarding claim 10, WO '731 discloses a method for fabricating electronic structures wherein a barrier layer **10** is formed on the bottom and side walls trenches **5** or vias of an insulating layer **8** (fig. 2A; page 12 to page 13). The electronic structure may include a semiconductor (substrate) covered with the insulating material (page 2). Copper is electroplated directly onto the barrier layer **10** (page 12, line 5). In an example depicting the enhancement of a thin seed layer, Figures 2B and 2C illustrate copper **18** being electroplated directly on the barrier layer **10** on the bottom and side walls in discontinuities present within a thin seed layer **15** (see fig. 2B and 2C). The electroplating bath is comprised of copper sulfate, as a source of cupric ions, and a complexing agent and may also contain other additives (page 16). The bath is maintained at a pH of at least 9.0 and can have a pH of 5-13 (page 17). The current density used for electroplating "can be 1 to 5 milliamps/cm^2", which contains the endpoint of the claimed range (page 18).

Regarding claim 13, the barrier layer **10** can be made of titanium nitride or tantalum nitride (page 12).

Regarding claim 14, the thickness of the barrier layer is approximately 100 to 300 Angstroms (10 to 30 nm), which is greater than 4 nm (page 13).

Regarding claim 16, the dielectric **8** is silicon dioxide (page 13).

Regarding claim 18, the temperature of the electroplating bath can be within a range of 20 to 35°C (page 18).

Regarding claim 19, copper sulfate is used as the source of cupric ions and EDTA is used as a complexing agent (page 17).

Regarding claim 20, potassium hydroxide or sodium hydroxide may be used to control the pH (page 17).

The method disclosed by WO '731 differs from the instant invention because WO '731 does not disclose the following:

a. Lithographically defining and forming recesses for lines and/or vias, as recited in claim 10;

b. The electroplating bath comprises cyanide ions, as recited in claim 10;

c. The electroplating bath comprises a stabilizing agent, as recited in claim 10;

d. A current density of 5 mA/cm^2 to 25 mA/cm^2, as recited in claim 10 (WO '731 teaches a current density of 5 mA/cm^2);

e. Copper deposited to provide a thickness of about 10 nm to about 100 nm, as recited in claim 11;

f. Copper deposited to provide a thickness of about 20 nm to about 50 nm, as recited in claim 12;

g. The barrier layer is tungsten, as recited in claim 15;

h. The recesses have an aspect ratio of greater than 3:1, as recited in claim 17;

i. The stabilizer is 2,2'-bipyridyl, as recited in claim 22;

j. The current density is about 10 to about 20 mA/cm^2, as recited in claim 29; and

k. The current density is about 15 mA/cm^2, as recited in claim 30.

Regarding claims 10, 29, and 30, WO '731 discloses that the current density can be "1 to 5 milliamps/cm^2 (page 18). LANDAU discloses a method for fabricating electronic structures comprising the step of forming an insulating layer **16** and forming recesses defining vias using a lithographic technique (fig. 1A-1E; col. 2, lines 34-57). A barrier layer **20** is formed on the insulating layer **16** and copper **22** is electroplated on top of the barrier layer **20** (col. 2, line 58 to col. 3, line 26). LANDAU teaches "plating/deposition is accomplished with a relatively low current density for a relatively long interval because low current density promotes deposition uniformity" (col. 15, lines 48-63). LANDAU discloses the use of current densities of about 5 mA/cm^2 to about 40 mA/cm^2 (col. 16, lines 21-24). LANDAU further teaches that a relatively low current density should be used at the beginning of the plating cycle and a higher current density as the thickness of the deposited layer increases (col. 16, lines 32-38). The current density is chosen to provide the desired uniformity.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have used lithographic technique for forming the recesses in the insulating layer of WO '731 as taught by LANDAU because lithographic techniques efficiently and accurately form patterns in insulating layers.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the current density in the method of WO '731 to use a current density of about 5 mA/cm^2 to about 25 mA/cm^2 because LANDAU teaches that the uniformity of the deposited copper can be controlled by the current density and that low current densities promote greater uniformity.

Regarding claims 10, 21, and 22, TING et al. discloses the use of an electroplating bath comprising copper sulfate, EDTA, potassium hydroxide, "RHODAFAC RE 610 or polyethylene glycol as a surfactant and wetting agent, and ammonium cyanide or 2,2'-dipyridyl as a stabilizer" (col. 10, lines 42-55).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the electroplating bath in the method of WO '731 to use surfactants and stabilizers as taught by TING et al. because TING et al. have shown that the use of a stabilizer and surfactant, e.g., ammonium cyanide and 2,2'-dipyridyl, in the electroplating bath would have promoted ductility and prevented the formation of nodules in the electroplated copper deposit, thus significantly advancing void-less fill of the via structure.

Regarding claims 11 and 12, the amount of copper that is plated is proportional to how long the method is applied with the current density that is used. As such, the thickness of the deposited layer is a variable controlled by the user. It is the overall method steps that are given patentable weight and not the structural limitations thereof unless the structural limitations materially alter the overall method (*In re Leesona Corp.*, 185 USPQ 156; *Ex parte Pfeiffer*, 1962 CD 408; *Ex parte Kangas*, 125 USPQ 419; *Ex parte Foreman*, 1924 CD 47; *Ex parte Nelson et al*, 82 USPQ 115; *In re Winder*, 1957 CD 175; *Ex parte Hart*, 117 USPQ 193). It does not appear that the overall method of WO '731 is significantly altered as a function of the thickness of the electrodeposited

layer. The method disclosed by WO '731 and the method of the instant invention are both processes for forming high aspect ratio damascene structures. As such, the thickness of the thus formed structure appears to be a matter of designer choice and optimization given the art known and technology definitions of size parameters of "high-aspect" microstructures. The electrolytic deposition of filling the recess is allowed to occur until a sufficient thickness is deposited.

Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to have used the method of WO '731 to deposit copper to a desired thickness such as 10 nm to 30 nm or more.

Regarding claim 15, TING et al. disclose a method for forming copper interconnect structures in electronic devices by plating copper over a barrier layer **30**, which is formed on an insulating layer **11** (fig. 3; col. 9, lines 52-65). The barrier layer **30** can be made of a material including tantalum, tantalum nitride, titanium, titanium silicon nitride, tungsten, tungsten nitride or other materials (col. 7, lines 29-31).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the barrier layer metal in the method of WO '731 to use tungsten as taught by TING et al. because tungsten is an equivalent barrier metal to other tantalum/titanium nitride materials disclosed by WO '731 and would be expected function equivalently.

Regarding claim 17, the method of WO '731 is used to fill vias and trenches **5** with copper. However, the aspect ratios of the microstructures are not disclosed. LANDAU teaches that the method of electroplating copper in vias can be used for filling structures having aspect ratios exceeding 4:1 (col. 1, lines 34-39).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have used the method of WO '731 to fill vias having aspect ratios exceeding 3:1 because LANDAU teaches that the plating method can be used to plate vias having aspect ratios exceeding 4:1.

(11) Response to Argument

Regarding Appellant's arguments, it is noted that Appellant repeatedly states that copper is plated directly on the barrier layer "in the absence of an intervening seed layer" (see pages 4-6 of Appellant's Brief). The claims of the application do not require the absence of a seed layer. The claims require only that copper is electroplated directly on the barrier layer. Therefore, a seed layer may be present in the method.

Regarding the primary reference (Chen = WO '731) used in the rejection of the claims, Appellant argues, "Chen teaches away from plating copper directly onto a barrier layer material" because "Chen relates to 'an alkaline electrolytic copper bath ... used to enhance an ultra-thin copper seed layer'" (see page 6 of Appellant's Brief).

While Chen teaches a method that does comprise enhancing an ultra-thin seed layer, Chen clearly discloses, "In accordance with the invention, an alkaline electrolytic

copper bath is used to electroplate copper onto a seed layer, *electroplate copper directly onto a barrier layer material*, or enhance an ultra-thin copper seed layer" (emphasis added by examiner; see WO '731 at page 12). Chen provides further details regarding plating copper onto an underlying barrier layer by stating "a copper layer plated at a higher plating potential in an alkaline bath provides greater adhesion to the underlying barrier than a copper layer plated at a lower plating potential in an acid bath" (see WO '731 at page 20).

Furthermore, the ultra-thin seed layer enhancement taught by Chen further demonstrates electroplating a copper layer directly on the barrier layer. As seen in Figures 2B and 2C of WO '731, the seed layer **15** is discontinuous and portions of the barrier layer **10** covering the bottom and side walls of the opening are exposed (see WO '731, figs. 2B and 2C). A copper layer **18** is electroplated directly onto the barrier layer **10** at these exposed portions (see WO '731, figs. 2B and 2C).

Therefore, Chen teaches that copper may be electroplated directly on the barrier layer. The copper layer may be plated directly on the barrier layer regardless of the presence of an ultra-thin seed layer.

Regarding both Landau and Ting et al., Appellant argues that both references require a seed layer (see pages 4-6 of Appellant's Brief). These arguments are not persuasive for two reasons. First, Ting et al. clearly teach, "The seed layer also functions as a barrier/adhesion layer for the subsequently plated Cu or Cu-base alloy"

(see page 4 of Appellant's Brief and U.S. Pat. No. 5,969,422 at col. 6, lines 41-47 and Abstract). Second, the instant claims do not prohibit the presence of a seed layer.

Appellant cites several teachings of Ting et al. to support this argument (see pages 4-5 of Appellant's Brief). The teachings cited by Appellant show that the seed layer of Ting et al. can be the barrier layer (see US '422 at col. 6, lines 41-47 as recited above). Ting et al. teach that the purpose of the seed layer is to carry electrical current for electroplating (see US '422 at col. 4, lines 19-21). Ting et al. further teach that the seed layer may be formed of refractory materials including tantalum, titanium, and tungsten, which are commonly used barrier materials (see US '422 at col. 6, lines 56-65).

Therefore, Ting et al. teach plating copper directly onto a barrier material. The term "seed" is used to denote conductive material that is required to electroplate copper because copper cannot be electroplated directly on a dielectric material.

Regarding the reference of Landau, Appellant argues that Landau teaches a seed layer (see pages 5-6 of Appellant's Brief). As explained above, the claims do not exclude the presence of a seed layer.

Furthermore, the teachings of Landau are relied upon to show the lithographic definition and formation of lines and/or vias and to demonstrate appropriate current densities. As one skilled in the art would readily recognize, these teachings are pertinent to methods involving seed layers as well as those methods that do not use seed layers. The formation of the lines and vias occurs before the barrier layer is even

deposited. WO '731 teaches a current density of 5 mA/cm^2 (see WO '731 at page 18). Landau teaches current densities of about 5 mA/cm^2 to about 40 mA/cm^2 (see U.S. Pat. No. 6,261,433 at col. 16, lines 21-24). Landau further teaches that a current density of about 5 mA/cm^2 should be used at the beginning of the plating process and that the current density should gradually increase as the deposition thickness increases (see US '433 at col. 16, lines 32-38). Therefore, the current density is dependent on the thickness of the material being plated.

Appellant's further argues that the prior art of record teaches away from the present invention because Ting et al. state, "[A] seed layer is required for plating copper onto a barrier layer" (see page 6 of Appellant's Brief). As explained above, both Chen (WO '731) and Ting et al. teach electroplating copper directly on a barrier material.

Appellant argues that "no such reasoning for the combination exists in the prior art, and nothing in the prior art would suggest the properties achieved by the present invention" and that "the prior art lacks the necessary direction or incentive to those of ordinary skill in the art to render a rejection under 35 USC 103 sustainable" (see page 7of Appellant's Brief). As explained above, one skilled in the art would be motivated to combine the prior art references in the manner described. As evidenced by the prior art references, the level of one of ordinary skill in the art at the time the invention was made is relatively high. Those skilled in the art of electroplating, especially in methods for fabricating electronic structures such as semiconductors and printed circuit boards,

posses a solid understanding of the materials (e.g., metals and additives) and operating conditions used in electroplating processes. One skilled in the art would have the necessary direction and incentive provided by the prior art of record to render the claimed method obvious.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

Brian L. Mutschler
June 23, 2004

Conferees
Nam Nguyen (SPE 1753)
Patrick Ryan (SPE 1745)

Connolly Bove Lodge & Hutz LLP
Suite 800
1990 M Street, N.W.
Washington, DC 20036-3425